Hi everyone! I'm so glad to be here today to talk to you about hazardous materials. My name is Hayley Monroe and I am an objects conservator, currently working at the Museum of Vancouver.

Before going any further, I'd just like to acknowledge that I work and live in Vancouver, British Columbia - a city on the unceded territory of the Musqueam, Squamish and Tsleil-Waututh First Nations.

Summary

- Introduction
- What makes a material hazardous?
- Hazardous materials common in museum and heritage collections
- Surveying your collection for hazardous materials
- Identification
- Management and safe working procedures

Just to summarize, today in this workshop I'll be covering the following topics. It's impossible to cover everything in only 45 minutes. So treat this as an introduction to the topic. There are really excellent resources out there, some of which I'll be mentioning in this talk, and in addition, this series is offering a full length course later in the summer, specifically on the risk management and health and safety aspects of this topic.

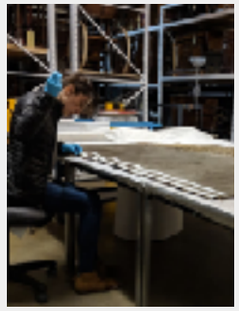
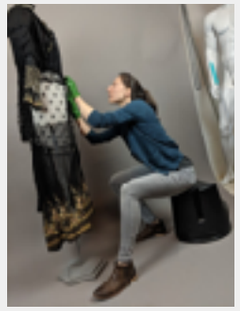
Unlike industrial workers who are likely to encounter higher doses of potentially hazardous materials resulting in acute exposure, ***museum workers are more likely to be exposed to low-level doses of heavy metals [and other toxins] over an extended period of time, resulting in chronic health problems.***

AIC Health and Safety, 2008

So why is it important to consider hazardous materials?

This statement from the AIC Health and Safety committee sums up the stakes well: (read quote)

So what this boils down to is the importance of limiting exposure as much as we can to keep ourselves and our coworkers as safe as possible while still being able to conduct the kinds of tasks crucial to collections work - like prepping exhibitions, completing conservation treatments, facilitate repatriations, etc.

Exhibition prep	Object photography	Complying with WorkSafe BC requirements	Storage reorganizations
			
DDT	**Naphthalene**	**Asbestos**	**Arsenic, mercury & lead**

Here are some images to just give you an idea of how routine exposure to hazardous materials can be while working in a collections space - here you can see myself and my colleagues engaged in normal daily collections tasks. And in each of these images, we are aware that we are working with hazardous materials.

What makes a material hazardous?

So what exactly makes a material hazardous?

When we say a material is hazardous it can mean many things. I've often run into old labels and records with vague warnings like "danger" or "poison" with little additional explanation.

The materials we encounter in collections can be roughly broken down into chemical hazards, physical hazards, and biological hazards

Chemical hazards are toxic - and toxicity itself can be broken down into a wide range of physiological effects including short-term or acute effects on various systems in the body, but also longer term or less immediately obvious effects such as carcinogenicity, reproductive toxicity etc. Chemical hazards include materials like pesticides, preservatives, heavy metals, ethnobotanical toxins, and the like.

Physical hazards are not toxic but pose the risk of harming the body physically. This includes flammable or explosive materials like cellulose nitrate, asbestos (which causes accumulated physical trauma to the lungs), and radioactive materials.

Biological hazards include infectious substances. In the western United States for example, hantavirus, which is spread by mice, is a worry in collection spaces. Biological hazards can also include other pathogens, such as those harbored in bird droppings, as well as moulds.

Hazardous materials commonly found in cultural collections:

Pesticides - organic and inorganic

Preservatives (for wet specimens)

Heavy metals (non-pesticide)

- Pigments
- Mercury-felted hats
- As associated with 19th C dying
- Solid lead and lead solder
- Corrosion products of lead and cadmium
- Liquid mercury
- Geological specimens

Asbestos

- Incorporated in objects and architectural elements
- Mineral specimens

Pharmaceuticals, patent medicines & controlled substances

Ethnobotanical and other biological toxins

- Poison darts/arrows, and herbaria
- Including: strychnine, aconite, ergot, curare, *Abrus precatorius*, etc. etc.
- Mold
- Pathogens (from contaminated objects)

Chemicals

- Historic industrial or household
- CTC-containing grenade-style extinguishers

Explosive and pressurized objects

- Firearms, ammunition, firecrackers, pressurized fire extinguishers, etc.

Cellulose nitrate & celluloid

Deterioration products of some plastics

Radioactive objects and specimens

Hazardous materials are very common in cultural heritage collections. As conservators, we're very aware of certain hazards - particularly pesticides and toxic pigments. But the range of common hazards is quite broad, here's a list of just a selection of things that you might routinely run into.

Evaluating your collection

So how do you go about evaluating your collection. You can’t really manage what you don’t know is there, so locating and identifying hazards in your collection is an important step.

Research!

- What have other museums identified?
- Historical information (ie. details of manufacture, or timelines of use for specific materials such as pesticides or pigments).
- Toxicological data

The best place to start is research! There is a wealth of resources available which are extremely helpful and help to build a familiarity with hazards and other institutions responses to them.

Research can also point you in the direction of some easy identifications. Take patent medicines and early pharmaceuticals. Sometimes hazards are obvious, sometimes they become obvious with a little additional information.

Once you know what to look for, some hazardous materials might begin to come out of the woodwork.

Surveying

- Walk your aisles, explore your records
- Visual and non-analytical positive IDs
- Likely IDs (good candidates for further testing and/or preemptive flagging)

Once you have an idea of what to look out for, the next most useful task is often to explore and survey your collection. Walk the aisles in storage and go through object records.

This is a good way to both quickly catch easy-to-identify hazards such as the highly toxic but very common Abrus precatorius seeds (shown here) or uranium glass (which can easily be identified with a UV light).

This is also as the best way to compile a list of likely or suspected hazards - meaning those materials you cannot identify with the naked eye, but which are good candidates for further testings. This includes objects you possibly treated with pesticides, commonly inherently hazardous objects such as taxidermy specimens or felted top hats and bowlers, or objects that might contain ethnobotanical toxins.

Analytical testing (when possible)

- Non-invasive techniques

  Such as X-Ray Fluorescence (XRF)

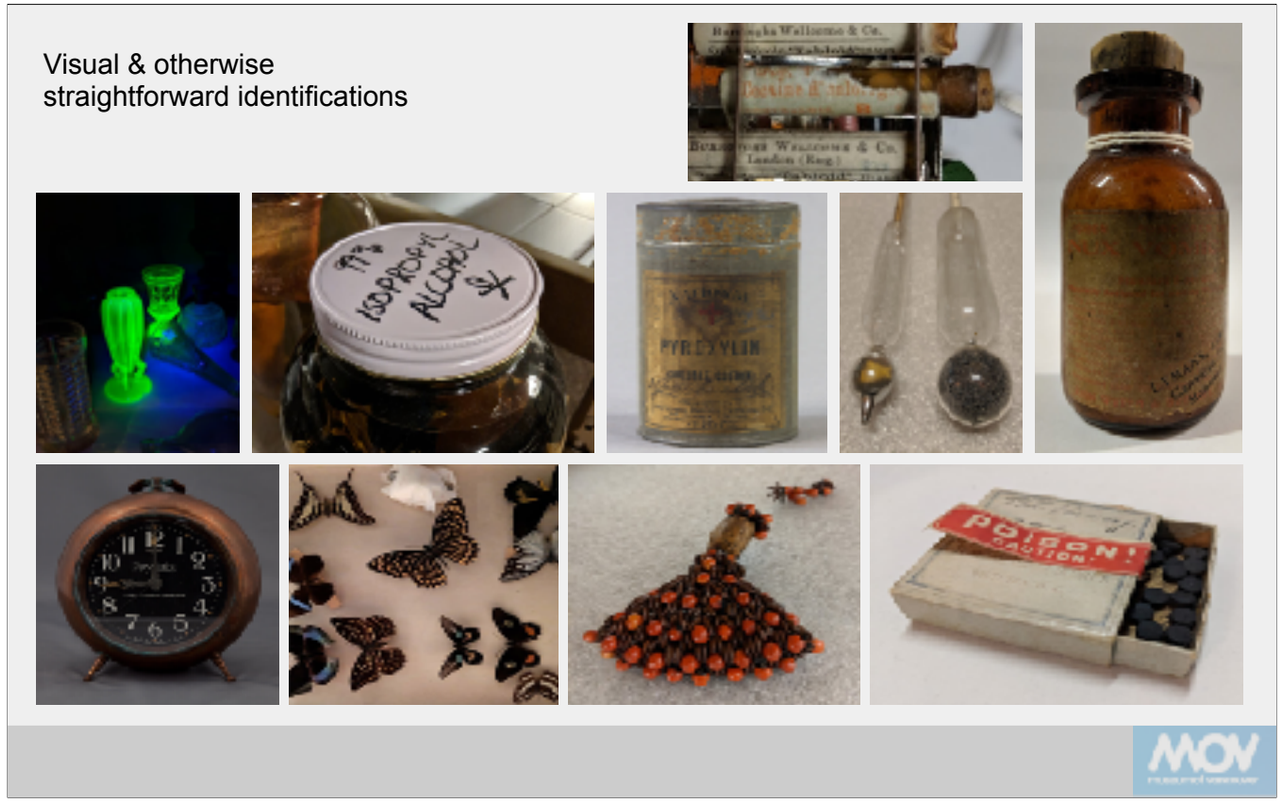
- Invasive techniques which require sampling

  (Such as GC-MS - especially for detecting organic molecules such as organic pesticides and ethnobotanical toxins)

And finally - analytical testings. The majority of hazardous materials can only be definitively identified by analytical means. Two very useful analytical techniques are x-ray fluorescence (or XRF) and Gas Chromatography Mass Spectrometry (or GC-MS). XRF is a non-invasive technique for detecting elements. And in the context of hazardous materials, it is particularly good for detecting heavy metals such as arsenic, mercury, and lead. Just remember, that it cannot identify specific compounds.

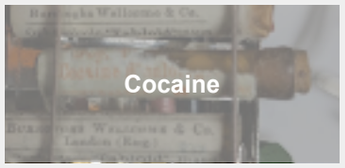
GC-MS on the other hand, is a minimally invasive technique (usually requiring a swabbed sample) particularly useful for the identification of organic compounds, and for our purposes, this includes organic pesticides (such as DDT or pentachlorophenol) as well as ethnobotanical toxins such as curare or strychnine.

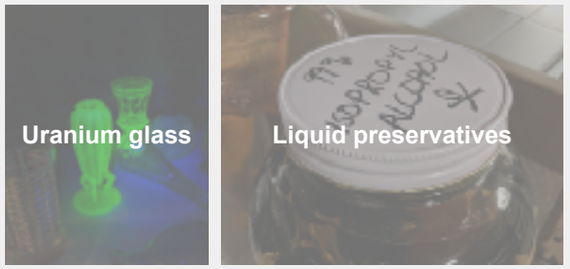
Of course many institutions do not have analytical equipment on hand. However this doesn't mean testing is impossible. In many cases it is possible to arrange for testing. Larger institutions and universities are often willing to loan equipment or run samples. And. here in Canada, CCI offers its services to museums for testing samples.

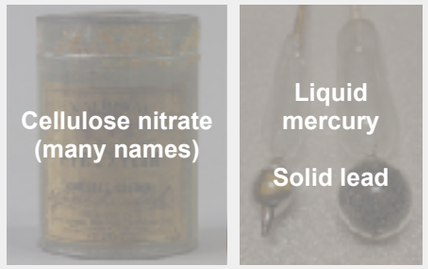


To give you an idea of the range of identifications you can make, let me show you three batches of objects all from the Museum of Vancouver, starting with easy identifications:

Visual & otherwise
straightforward identifications





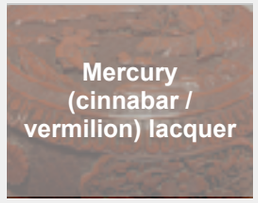


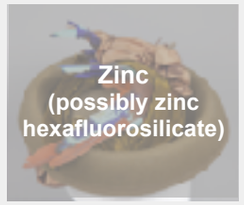
XRF

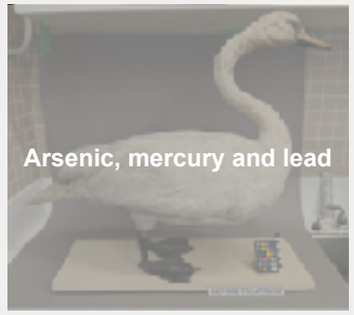
Non-invasive elemental analysis

XRF

Non-invasive elemental analysis





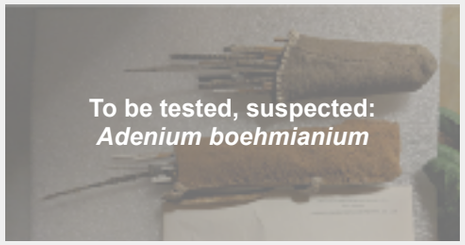


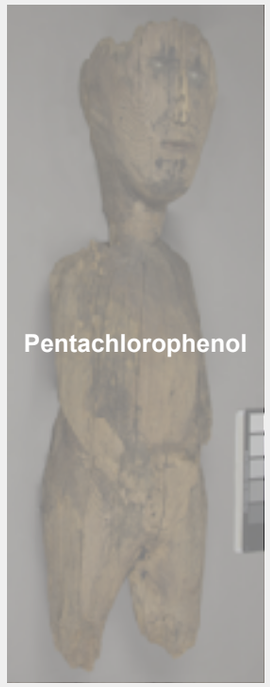
GC-MS

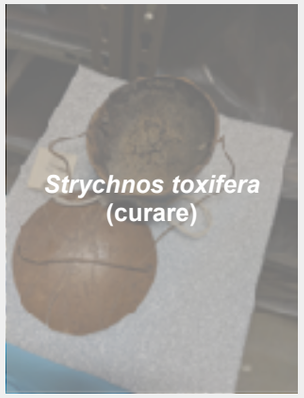
Minimally invasive analysis of organic molecules

GC-MS

Minimally invasive analysis of organic molecules







Just how dangerous *is* that object?

With identification out of the way - Just how dangerous are these objects?

(The hands pictured in this medical plate from 1859 show ulcers and discoloration caused by working with arsenical Scheele's green)

Hazard vs. Risk

What's the difference?

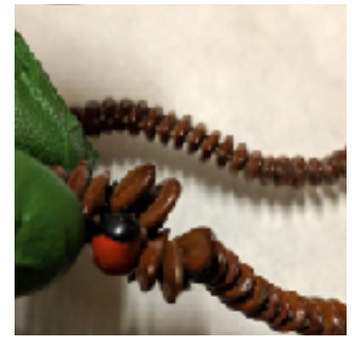
Hazard: *a dangerous property*

- Chemical hazards such as toxicity, carcinogenicity, reproductive toxicity, etc.
- Physical hazards such as flammability, radioactivity, pressurization, etc.

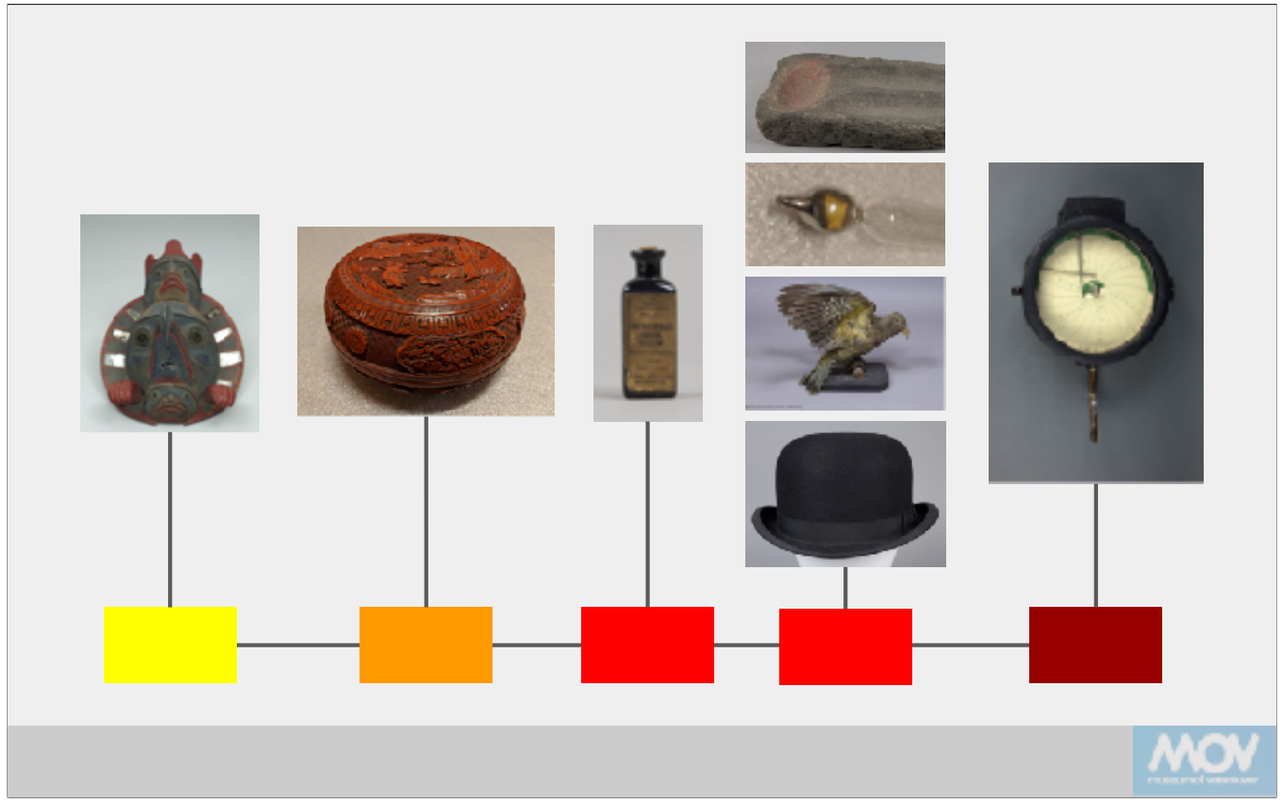
Risk: a combination of the hazardous property and the *likelihood and degree* of exposure

When evaluating the danger posed by an object, it's important to keep in mind the difference between hazard and risk. Essentially, this refers to the difference between the fact that a material is hazardous versus how likely it is to cause harm.

And of course, an industrial hygienist is someone who can provide detailed guidance on this front. But there are definitely places that we can begin.



Here are some examples of hazards with very different routes of exposure:



Often times the same hazard can present different ways. Take mercury for example. It is both very common in cultural heritage collections and appears in a wide range of forms, from pigments to pesticides to elemental liquid mercury, to an ingredient in patent medicines.

The compound mercury is present in also influences not only how toxic it is but also its easiest route of exposure into our bodies.

Here are some examples arranged by the ranks we assigned them in our museum:

Of least concern were our painted objects and lacquers. Cinnabar and vermilion (which are chemically identical, both are mercury sulfide) emits a small amount mercury vapor. These objects do not pose a great handling risk, and can be easily bagged or otherwise housed to reduce exposure to the vapor. Then we have objects such as the patents medicines, which we are cautious of mostly because we do not know the risk they'd pose if they were to break and spill (they often also contain additional hazardous extracts which complicate the picture). We also have powdering pigments, which obviously poses a greater risk than an intact paint layer, delicate instruments containing larger amounts of liquid mercury (safe until broken), as well as taxidermy specimens and top hats which post a substantial risk of dermal exposure through handling (as well as accidental ingestion if people do not practice proper hygiene).

And finally we have leaking our broken and leaking mercury instruments. These, again mostly pose an inhalation risk of mercury vapor, and these actually exceed our city WorkSafe guidelines and we have bagged and sequestered these objects.

Managing the Hazards in Your Collection

- Labels and database records (tagging and flagging)
- Storage and housing upgrades
- Safe working practices and PPE

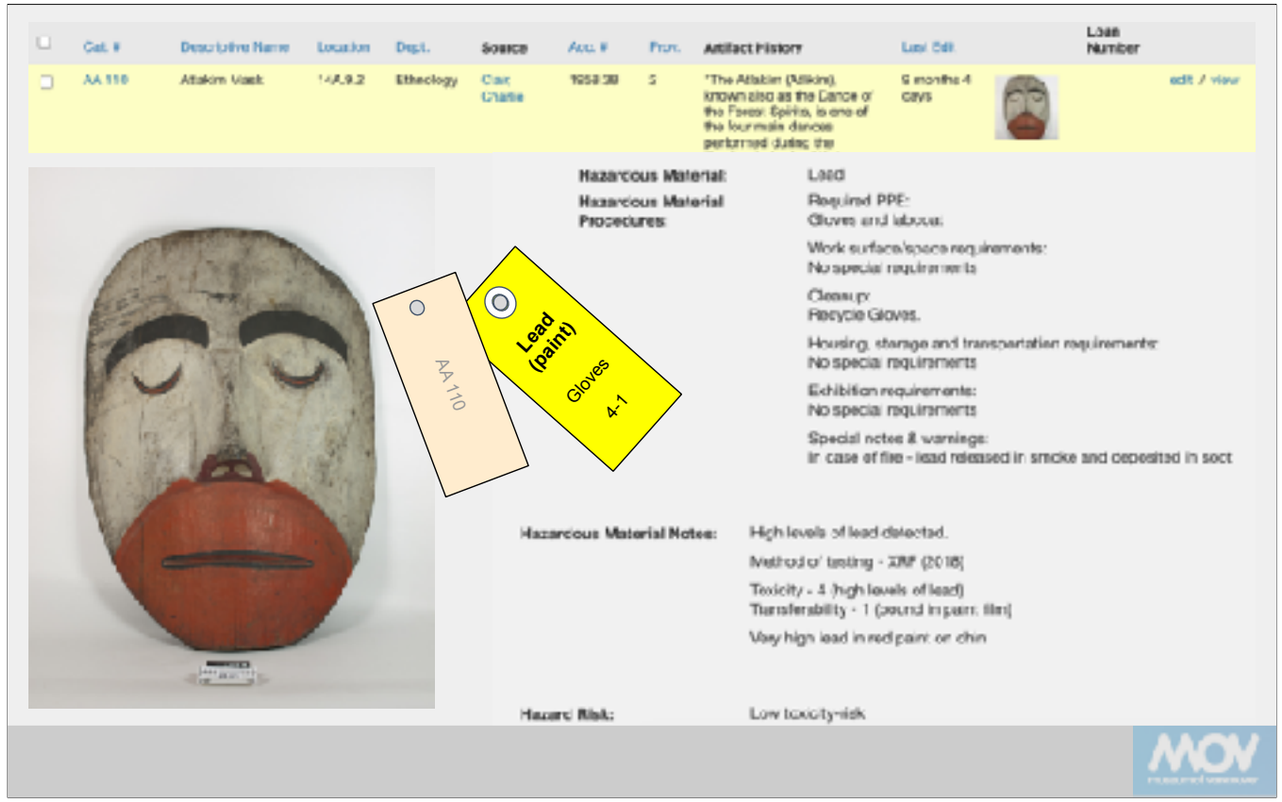
So once you've identified hazards in your collection. What should you do about them? I'm going to go into some straightforward first steps to improve safety and to reduce exposure. These steps can be taken no matter your budget, requiring only inexpensive materials.

What I won't dive into is the much broader picture of risk management - designing protocols etc. Kerith's course later in the summer will be an excellent resource for that. But this should give you a place to start.

Labels and database records

One of the most important things you can do is transmit the information! This includes physically tagging objects with labels that include useful information, such as the hazard present and handling requirements or restrictions (do not overuse use skull and crossbones icons! this dilutes the meaning of the symbol which is important for those hazards which are truly acutely dangerous).

As you can see, this sometimes results in an alarming visual, but in the case of the mercury-felted hats, the warning is justified, and the ultimate goal is to rehouse all of these so they’re not hanging out in the open.



Database records are also very important. Here I have an example from our own database.

Here you can record important information and ensure that it is available to all staff. You might include color coding to visually alert the user, the hazard present, the date of testing and the results, as well as tagging and handling requirements and any restrictions.

The example here is a mask with lead paint. It is sound and poses little handling risk…. In contrast...

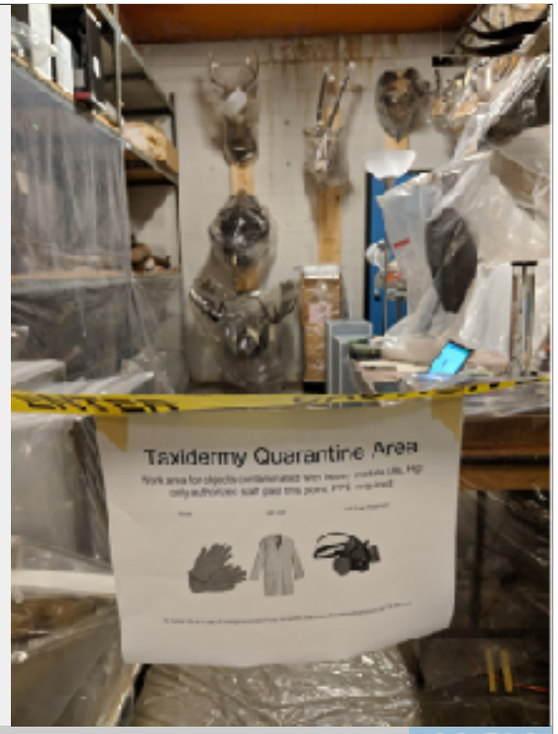
We have a poorly sealed bottle of lead flake white powder. As you can see, the alert is red, and the handling requirements are far stricter.

Storage and housing upgrades

The purpose of storage and housing upgrades is to minimize exposure to hazardous materials. This might be as simple as preventing unnecessary contact with an object by storing it in a box or bag, or by limiting access to its location, as in the case of radioactive collections. Exposure can also be minimized by bagging materials which emit toxic vapors, in particular, objects painted with cinnabar or vermilion pigment which emit mercury vapor. And by protecting fragile objects which would pose a greater risk if they break - such as instruments that contain liquid mercury or patent medicines which can contain a host of toxic extracts and heavy metals.

Additionally, simple but important upgrades such as padded boxes and earthquake barriers on shelving (either purchased or made in house) are very important if you work in a seismic zone. This will hopefully prevent fragile hazards such as wet specimens, patent medicines and instruments with liquid mercury from falling and smashing in the event of a shake).

Safe Working Practices



Having hazardous materials in your collection does not mean you cannot work with them. Like safe housing and storage, employing safe working practices greatly helps to reduce exposure to yourself and your staff.

Some simple but effective practices include:

- Only working with hazardous collections when you need to - avoid unnecessary contact
- When working with hazards that pose a high risk of cross contaminations (such as taxidermy specimens), work within a quarantine zone. Ideally, lay down some polyethylene sheeting on your work table, and ensure that the area is cleaned afterwards, either wiped down or ideally vacuumed with a HEPA filtered vacuum.
- Wear appropriate PPE...personal protective equipment is your last line of defense, not your first. But it is no less important.

Make sure you have the basics on hand - nitrile gloves, lab coats and fitted respirators. For many tasks, a coat and gloves are sufficient, but it is important to have respirators on hand when dealing with pesticides and heavy metals especially.

Be aware that there are different types of filters, and it is good to have a variety. Particulate filters are for heavy metals and particles. Organic vapour filters will protect you from volatile organic compounds like naphthalene, formaldehyde and solvents. Mercury vapor requires special filters for that purpose - but it is best to not get yourself into situation in which you are exposed to that much mercury vapour in the first place.

In combination, safe handling and working practices plus personal protective equipment can greatly reduce your exposure to hazardous materials.

And finally, personal and workspace hygiene are vital. Contaminated lab coats should be collected and laundered (not draped over your office chair). Work spaces and tools like table tops, door knobs, pencils, etc should be wiped down or cleaned regularly with a HEPA vacuum. And you should ALWAYS wash your hands after leaving the workspace and before touching your eyes, nose or mouth and before eating.

Ideally, contaminated PPE and packing materials should be disposed of properly - you don’t want to put pesticide and heavy metal residue into the waste stream - and these should be collected until you can arrange for a company to pick them up. This is an additional cost, but it is ultimately worth it.

Thank you!

I hope this has been helpful! Of course it is hard to cover everything in 45 minutes, but I hope this has given you not only a glimpse into the work of hazardous materials but also emphasised that while a place for caution and care, it is also an aspect of collections that can be managed and worked with safely.